FORM PTO-1390 (REV 12-2001) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S APPLICATION NO. (If known, see 37 CFR 1 5)
258763-454-15635	10/049956

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB00/03203	17 August 2000	17 August 1999

TITLE OF INVENTION
HYDROCYCLONE

APPLICANT(S) FOR DO/EO/US
SMYTH, Ian C., THOMPSON, Peter A.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☑ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☑ Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☑ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☐ Other items or information:

JC10 Rec'd PCT/PTO 19 FEB 2002

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/049956	PCT/GB00/03203	258763-454-15635

21. ☑ The following fees are submitted:

	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	11 - 20 =	0	x **$18.00**	$ 0	
Independent claims	1 - 3 =	0	x **$84.00**	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$ 0	
TOTAL OF ABOVE CALCULATIONS =				$ 0	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$ 0	
SUBTOTAL =				$ 890	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 890	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0	
TOTAL FEES ENCLOSED =				$ 890	
				Amount to be refunded:	$
				charged:	$

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 03-3923 in the amount of $ 890 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 03-3923 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Michael J. Brown
Curtis, Mallet-Prevost, Colt & Mosle LLP
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New York, New York 10178-0061

SIGNATURE

Michael J. Brown
NAME

37,100
REGISTRATION NUMBER

HYDROCYCLONE

FIELD OF THE INVENTION

The field of this invention relates to cyclonic separation of solids from liquids or liquids from liquids.

BACKGROUND OF THE INVENTION

Cyclones have been in use in separation applications in a variety of industries for many years. Typically, these devices have a cylindrical body tapering to an underflow outlet, with a tangential or involute entrance and a centrally located end connection for the overflow fluids at the head end of the hydrocyclone. These devices are used to separate fluids of different densities and/or to remove solids from an incoming stream of a slurry of liquid and solids, generally concentrating the solids in the underflow stream.

Over the years, many efforts have been undertaken to optimize the performance of hydrocyclones. Performance increase could be measured as an increase in throughput without material sacrifice in the degree of separation desired for a given operating pressure drop. An alternate way to measure improved performance is to increase the separation efficiency for a given inlet flow rate and composition.

In the past, a cyclone has been provided with a single ramp presenting a generally planar face extending at a relatively shallow angle to a radial plane of the hydrocyclone and thus inclined toward the underflow end of the hydrocyclone. Thus, when the fluid enters from the inlet, the fluid swirls about the

axis of the chamber, with the back wall imparting to the mixture an axial velocity component in the direction toward the underflow outlet. This design is illustrated in PCT application WO97/05956. Also relevant to a general understanding of the principles of operation of hydrocyclones are PCT applications WO97/28903, WO89/08503, WO91/16117, and WO83/03369; U.K. specification 955308; U.K. application GB 2230210A; European applications 0068809 and 0259104; and U.S. patents 2,341,087 and 4,778,494.

In the past, a single helix of a uniform pitch was used to present an inclined surface to the incoming mixture. The inclined surface terminated at a step after the incoming mixture had undergone a complete revolution within the separating chamber. Thus, this prior design, illustrated in PCT application WO97/05956, took the entire incoming fluid stream and imparted a generally uniform velocity axial component to the generally helical flowpath of that entire incoming stream.

However, applicants' detailed studies of the axial flow of the fluid after it enters the hydrocyclone have revealed that, as viewed in a radial direction from the longitudinal centerline of the hydrocyclone, a preferred flow pattern would be nonuniform, with the greatest velocity being adjacent the peripheral wall of the hydrocyclone. Moving in radially from the outer periphery toward the longitudinal axis, the axial velocity component of the fluid mass decreases until it undergoes a reversal in direction representing the fluid stream that is heading toward the overflow outlet.

Accordingly, in seeking further capacity or efficiency improvements, one of the objectives of the present invention was to minimize turbulence internal to the hydrocyclone and thereby increase its performance. The capacity

improvement was achieved by recognizing that in order to minimize turbulence, the incoming fluid stream should be driven axially at different velocities, depending on the radial placement of the stream within the body. Accordingly, the objective of improving throughput and/or separation efficiency has been accomplished in the present invention by recognizing this need to reduce turbulence and accommodating this performance-enhancing need by a specially designed back wall ramp featuring multiple side-by-side spiraling slopes, the steepest slope being furthest from the longitudinal axis with adjacent slopes becoming shallower as measured radially inwardly toward the longitudinal axis. Those skilled in the art will more fully appreciate the significance of the present invention by a review of the detailed description of a preferred embodiment thereof below.

SUMMARY OF THE INVENTION

An improvement is made in the efficiency and/or throughput of a hydrocyclone by providing a back wall which imparts a greater axial velocity component to the fluids at the periphery as measured radially from the longitudinal axis of the hydrocyclone and a lesser axial velocity component to portions of the incoming fluid stream closer to the longitudinal axis of the hydrocyclone. More particularly, the back wall should correspond generally to the swirl pattern within the hydrocyclone, a combination of axial and tangential velocity components, to enable the incoming fluid stream to reach the desired flow pattern more quickly and efficiently than otherwise possible.

By way of example, specific embodiments in accordance with the invention will be described with reference to the accompanying drawings in which:-

Figure 1 is an elevation view showing the different degrees of inclination of the outer and inner ramps.

Figure 2 is the view along lines 2–2 of Figure 1, showing the ramps from the underside looking up toward the overflow outlet.

Figure 3 is a perspective view, in part cutaway, illustrating the two ramps at different angles.

Figure 4 is a schematic representation of the velocity distributions in the axial direction shown superimposed on a section view through the overflow and underflow connections, with an alternative embodiment of a curved ramp.

Figure 5 is a section view through the ramp, showing that at any given section, the radial line from the longitudinal centerline coincides with the ramp surface.

Figure 6 is similar to Figure 5 except the two ramps shown are disposed when a line is extended across their surface in any given section across the longitudinal axis at an angle toward the longitudinal axis.

Figure 7 is an alternative embodiment of a multiple–ramp structure shown in the other figures, showing the ability to provide a greater axial component to the fluid stream furthest from a longitudinal axis and a lesser component closer to the longitudinal axis by having a surface with curves or arcs so as to make a smoother rather than a step–wise transition from one ramp to the other as shown, for example, in Figures 1 and 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The hydrocyclone **10** has an inlet **12** which can be tangential or an involute, as illustrated in Figure 3. One or more inlets can be used. The incoming flow stream is exposed to a steeper outer ramp **14**, as well as the shallow or inner ramp **16**. Figure 2 better illustrates the inlet **12** and the placement of the outer ramp **14** closest to the housing **18**. A longitudinal axis **20** extends from the underflow exit **22** to the overflow exit **24**. A wall **26** marks the inside of the inner ramp **16** and spirals around longitudinal axis **20** in a general direction parallel to longitudinal axis **20** in view of the fact that the body **18** is generally cylindrical in the area of ramps **14** and **16**. In the embodiment illustrated in Figure 2, there are two inlets and the length of ramps **14** and **16** is generally 180°. Due to the spiraling orientation of ramps **14** and **16**, they wind up radially adjacent to the opposing inlet by the time they have made a 180° turn inside the body **18**. Figure 2 also illustrates the inner ramp **16** extending from the lower end of wall **26** and spiraling around in the same manner as the outer ramp **14** but at a different pitch, as illustrated in Figures 1 and 3. Accordingly, that portion of the inlet fluid which is ramped by the inner ramp **16** is ramped at a far shallower angle than the fluid which is radially furthest from the longitudinal axis **20** which is ramped by the outer ramp **14**. The provision of the dual-ramp design minimizes internal turbulence within the hydrocyclone **10** and thus improves the throughput and/or efficiency of separation of a given body design. Test comparisons of an identically configured hydrocyclone for separating oil from water, having a single inner 3° ramp compared to the same design with both a 3° inner ramp and a 10° outer ramp were undertaken. Test results indicated an increase in capacity,

over a baseline hydrocyclone without such ramps, of 3% for the single-ramp design rising to 8% for the dual-ramp design without significantly affecting separation.

Referring now to Figure 3, the overflow outlet **50** is depicted aligned with centerline **20**. The low ramp **16** is shown transitioning to the back wall **52**. Back wall **52** can be flat and in a plane perpendicular to the longitudinal axis **20**, or alternatively, it can be concave looking up or concave looking down with respect to the underflow connection **22** or overflow connection **24**. The inner low ramp **16** can be configured to smoothly transition into the back wall **52**, or they could be at different angles, all without departing from the spirit of the invention.

Figure 4 illustrates conceptually the change in axial component velocity measured on a radial line from the inside wall of the body **18** to the longitudinal centerline **20**. Figure 4 illustrates that the downward axial component is greatest along the inside of wall **18** and diminishes in quantity in a downward direction until it undergoes a reversal at point **28**. Thereafter, arrow **30** illustrates that a velocity increase in the opposite direction toward the overflow connection **24** is realized. The concept behind the multiple ramp of the present invention is to mimic as closely as possible the velocity profile illustrated in Figure 4, also allowing for changes in the tangential velocity profile. This can be accomplished with two or more ramps at different grades, disposed adjacent each other and extending from the inside of body **18** to centerline **20**. Rather than having discrete ramps with differing grades disposed adjacent to each other with walls spiraling generally a fixed distance from the centerline **20**, the ramp of the present invention can also be designed as a

continuous member which eliminates the step changes between the ramps which are taken up by wall **26**, for example, as shown in Figure 2. Instead, as shown in Figure 4, the ramp **32** can have a steeper gradient adjacent the inner wall of body **18** and a shallower gradient toward the centerline **20**, yet be composed of a more unitary construction with smoother transitions from one ramp gradient to the next and can employ curved surfaces for making such transitions, as schematically illustrated in the section view of Figure 4.

Figures 5, 6, and 7 illustrate alternative embodiments. Figure 5 corresponds to the dual-ramp design shown in Figure 2, shown in one specific section view through the hydrocyclone. In this embodiment, a line drawn parallel to the ramp surface at that particular section will wind up crossing the centerline **20** at approximately 90°. The change made to the ramp in Figure 6 is to basically present the multi-slope ramp in an inclined position such that a line parallel to the ramp surface in any particular section intersects the centerline **20** at some angle other than a right angle, as suggested in Figure 5. Figure 7 again indicates that step-wise changes between ramps can be vertical walls, as shown in Figure 5, or can be one or more arced surfaces to make the transition from a greater axial component toward the wall to a lesser one toward the centerline.

Accordingly, the provision of dual ramps makes a measured improvement in the capacity without sacrificing separation efficiency. The width of each ramp and the absolute angle with respect to the inlet **12** can be varied and the relative angles can also be varied without departing from the spirit of the invention. As previously stated, optimally for the particular design described above, the ramp angles are 3° and 10° for the inner and outer ramps

16 and 14, respectively. The ratio of gradients of the outer ramp 14 to the inner ramp 16 can be as low as about 1:2 and as high as about 1:5. With only a single inlet, the ramps can extend longer than 180° and can go around 360°.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made without departing from the scope of the invention.

CLAIMS

1. A hydrocyclone, comprising:

a body having an inlet at the periphery of the body, an adjacent back wall through which there is a central overflow connection and a central underflow connection at the opposite end of the body;

the overflow back wall presenting an inclined face for redirecting the stream of fluid entering the hydrocyclone to flow axially along the hydrocyclone in at least two different paths having at least two axial velocity components for improved phase separation performance.

2. The hydrocyclone of claim 1, wherein:

said body having a longitudinal axis extending from said overflow connection to said underflow connection;

said face comprises a radially inner portion and a radially outer portion, each defining a generally helical surface at a distinct slope extending from adjacent said inlet toward said underflow connection.

3. The hydrocyclone of claim 2, wherein:

said inner radial portion extends at a shallower slope toward said underflow connection than said outer radial portion.

4. The hydrocyclone of claim 3, wherein:

the slope of said outer radial portion extends at more than twice the slope of that of said inner radial portion.

5. The hydrocyclone of claim 2, further comprising:

a wall disposed generally equidistant from said longitudinal axis and marking a boundary between said inner and outer portions of said face.

6. The hydrocyclone of claim 1, wherein:

the end wall face comprises three or more radial portions.

7. The hydrocyclone of claim 6, wherein:

the slope of each radial portion is greater than that of the portion spaced radially inwardly thereof.

8. The hydrocyclone of claim 1, wherein:

the end wall face presents a generally smooth, continuous surface.

9. The hydrocyclone of claim 1, wherein:

at least a portion of the end wall face is inclined relative to the longitudinal axis of the hydrocyclone.

10. The hydrocyclone of claim 2, wherein:

said helical surfaces are flat.

11. The hydrocyclone of claim 2, wherein:

said helical surfaces are curved.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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International Bureau

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

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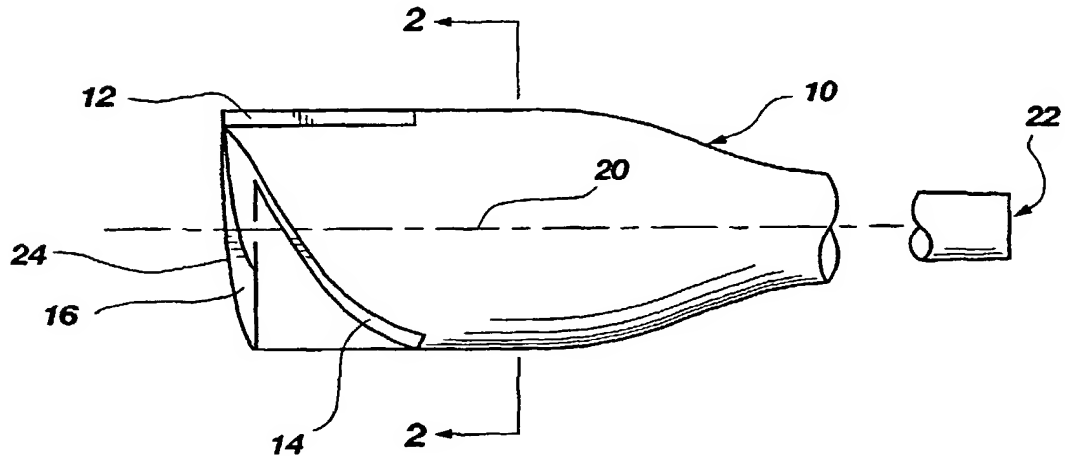
Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HYDROCYCLONE



(57) Abstract: An improvement is made in the efficiency and/or throughput of a hydrocyclone (10) by providing a multi-sloped back wall ramp (14, 16) which imparts a greater axial component to the fluids at the periphery as measured radially from the longitudinal axis (20) of the hydrocyclone and a lesser axial component to portions of the incoming fluid stream closer to the longitudinal axis of the hydrocyclone.

WO 01/12334 A1

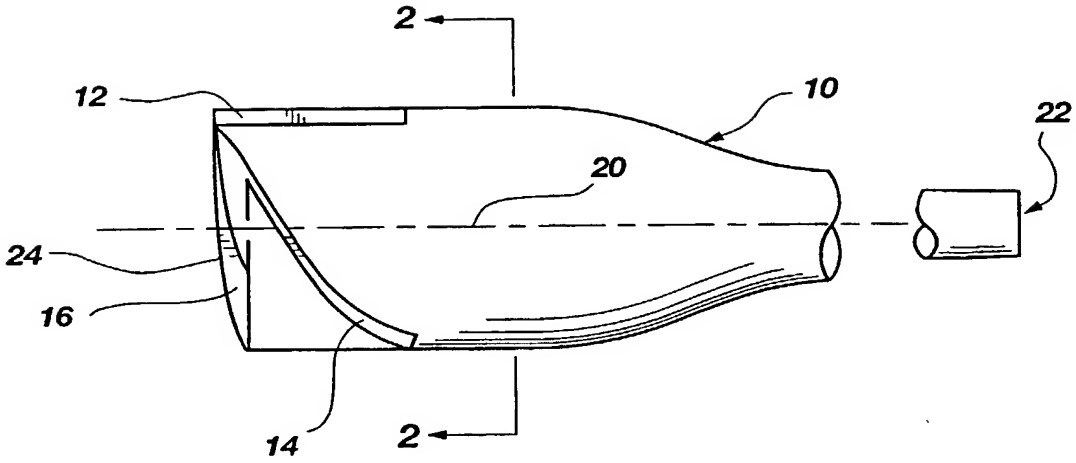


Fig. 1

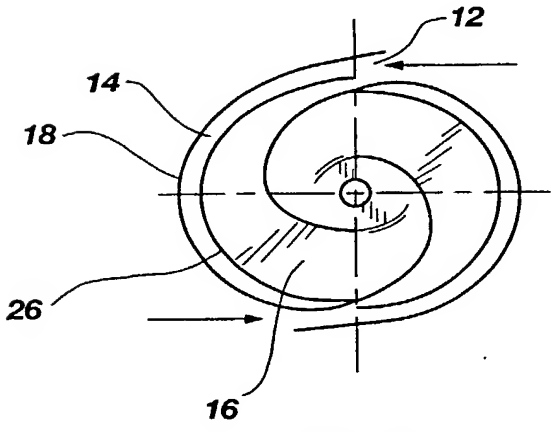


Fig. 2

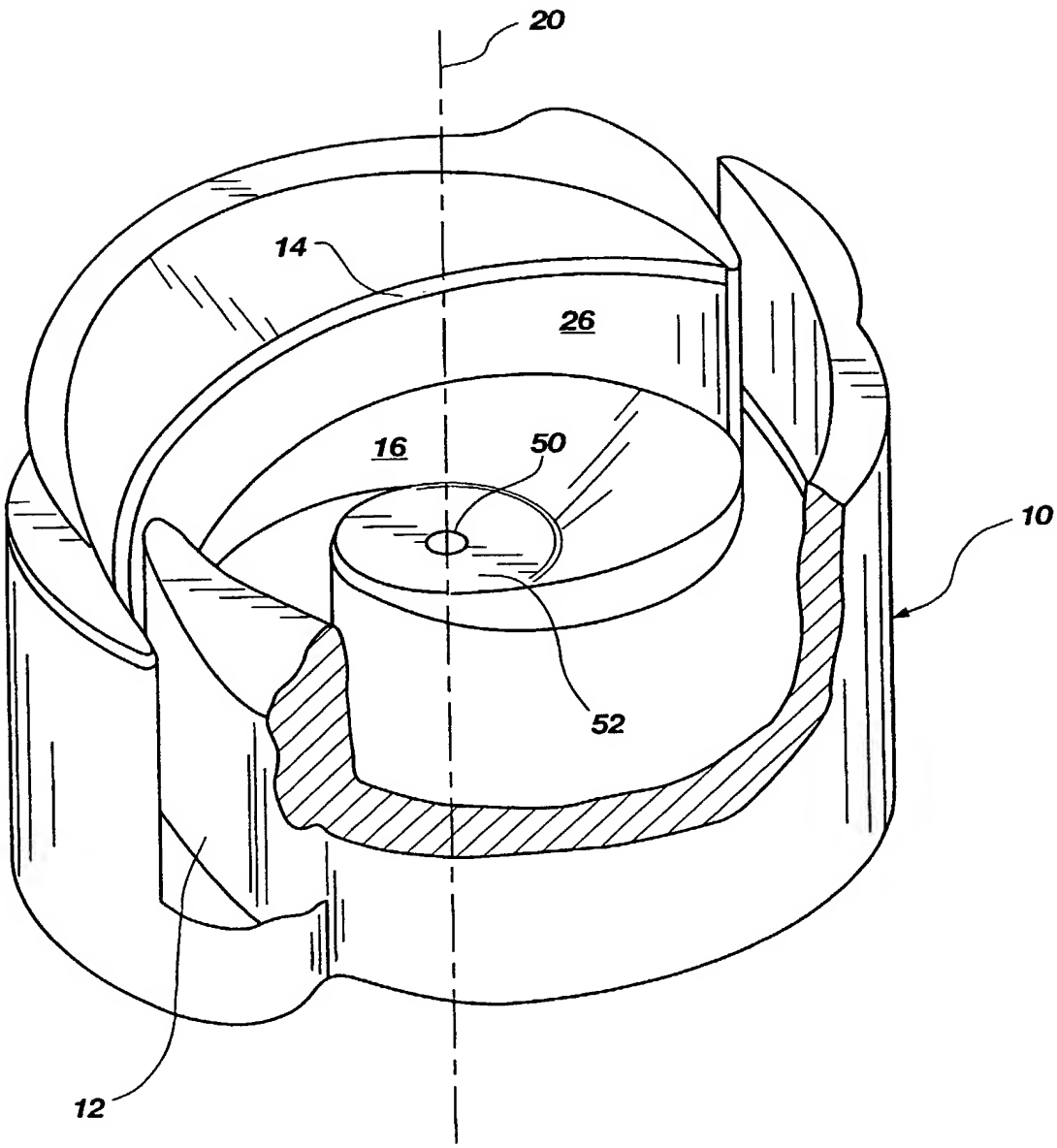


Fig. 3

3/4

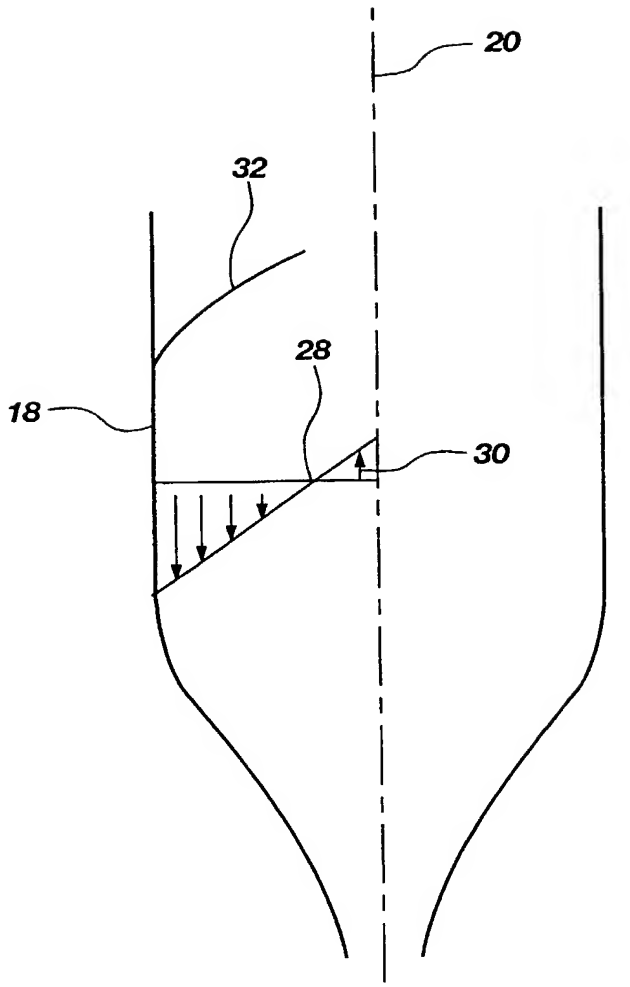


Fig. 4

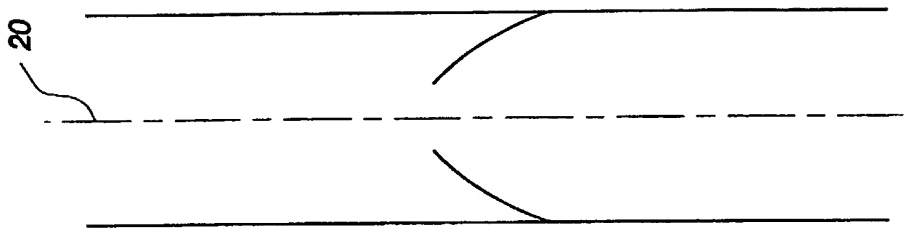


Fig. 7

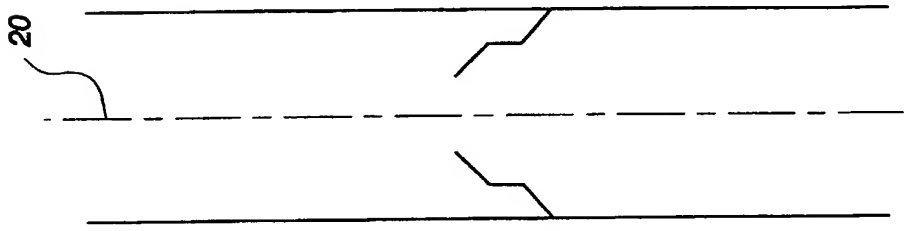


Fig. 6

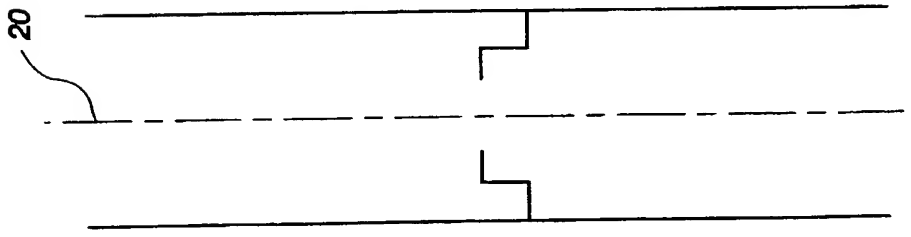


Fig. 5

PTO/SB/01 (03-01)
Approved for use through 10/31/2002 OMB 0651-0032
U S Patent and Trademark Office; U S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	258763-454-15635
First Named Inventor	SMYTH
COMPLETE IF KNOWN	
Application Number	10 / 049,956
Filing Date	August 17, 2000
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

HYDROCYCLONE

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 02/19/2002 as United States Application Number or PCT International Application Number 10/049,956 and was amended on (MM/DD/YYYY) _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1 56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	Certified Copy Attached? NO
9919462.3	UK	08/17/1999	☐	☐	☑
PCT/GB00/03203	PCT	08/17/2000	☐	☐	☑
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto

PTO/SB/01 (03-01)
Approved for use through 10/31/2002. OMB 0651-0032
U S Patent and Trademark Office: U S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it contains a valid OMB control number

DECLARATION — Utility or Design Patent Application

Direct all correspondence to: ☑ Customer Number or Bar Code Label	24229	OR ☐ Correspondence address below	
Name	Michael J. Brown Curtis, Mallet-Prevost, Colt & Mosle LLP		
Address	101 Park Avenue, 34th Floor		
City	New York	State NY	ZIP 10178-0061
Country US	Telephone (212) 696-6000	Fax (212) 697-1559	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

NAME OF SOLE OR FIRST INVENTOR :	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any]) Ian C.	Family Name or Surname SMYTH		
Inventor's Signature			Date
Residence: City	State	Country	Citizenship
Mailing Address			
City	State	ZIP	Country
NAME OF SECOND INVENTOR:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any]) Peter A.	Family Name or Surname THOMPSON		
Inventor's Signature C.A. Thompson GB3			Date 02 APR 2002.
Residence: City GLOUCESTER	State GLOS.	Country U.K.	Citizenship U.K.
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City	State	ZIP GL2 0EN.	Country U.K.

☐ Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

2-00

PTO/SB/01 (03-01)
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DECLARATION — Utility or Design Patent Application

Direct all correspondence to: ☑ Customer Number or Bar Code Label 24229 OR ☐ Correspondence address below

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

NAME OF SOLE OR FIRST INVENTOR: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any]): Ian C. | Family Name or Surname: SMYTH

Inventor's Signature: [signature] GB3 | Date: 13/03/02

Residence: City: WINCHESTER | State: HAMPSHIRE | Country: UK | Citizenship: BRITISH

Mailing Address: ST. CHRISTOPHERS, CHURCH LANE, EASTON

City: WINCHESTER | State: HAMPSHIRE | ZIP: SO21 1EJ | Country: U.K.

NAME OF SECOND INVENTOR: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any]): Peter A. | Family Name or Surname: THOMPSON

Inventor's Signature | Date

Residence: City | State | Country | Citizenship

Mailing Address

City | State | ZIP | Country

☐ Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Smyth, Ian C. et al

Serial No.	:	10/049,956	Examiner: Unassigned
Filed	:	Feb. 19, 2002	Art Unit: Unknown
For	:	HYDROCYCLONE	

POWER OF ATTORNEY

Petreco International Ltd., the owner of the above-identified application by an assignment recorded at Reel 012682, Frame 0550, hereby appoints: **Michael J. Brown, Registration No. 37,100**, as its attorney with full power of substitution and revocation to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith.

Please send all correspondence to:

Michael J. Brown
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Email: mbrown@cm-p.com

The undersigned is an officer of Petreco International Ltd. and is authorized to sign on its behalf. The undersigned specifies that the above assignment has been reviewed and certifies that, to the best of my knowledge and belief, title to said application is in Petreco International Ltd.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the

like so made are punishable by fine or imprisonment, or both, under Section 1001 of title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Petreco International Ltd.

Dated:

By: _____

Nicholas Winterbourne
Operations Director